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14. ABSTRACT

An acoustical assessment was performed on the Combat Arms Firing Range at Whiteman AFB in April 2013. It was determined that the noise in the firing range met the definition of impulse noise in AFOSH Standard 48-20; however, CATM instructors and students are still potentially exposed to peak sound pressure levels that exceed the allowable limits of AFOSH Standard 48-20. Therefore, it was recommended that hearing protection, either single or double, be worn during weapons live-fire training.

15. SUBJECT TERMS

Impulse noise, impact noise, decay time, CATM, firing range, hearing, acoustics, noise, firearms

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DEPARTMENT OF THE AIR FORCE
USAF SCHOOL OF AEROSPACE MEDICINE (AFMC)
WRIGHT-PATTERSON AFB OH

20 June 2013

MEMORANDUM FOR 509 MDOS/SGOJ
ATTN: LT JAIME DELRIO
1051 VANDEN BERG AVE
WHITEMAN AFB, MO 65305

FROM: USAFSAM/OEC
2510 Fifth Street
Wright-Patterson AFB, OH 45433

SUBJECT: Consultative Letter, AFRL-SA-WP-CL-2013-0016, Acoustical Evaluation of Combat Arms Firing Range, Whiteman AFB, Missouri

1. INTRODUCTION:

a. *Purpose*: On 15-18 April 2013, the United States Air Force School of Aerospace Medicine, Consultative Services Division (USAFSAM/OEC), at the request of AFGSC/SGPB and 509 MDOS/SGOJ, conducted an acoustical evaluation of the Combat Arms Training and Maintenance (CATM) firing range facility at Whiteman AFB, Missouri. The process of assessing impulse noise at a CATM firing range is a very complex task using specialized equipment to assess hazardous noise environments. USAFSAM/OEC is the only AF resource with both the skilled personnel and equipment to accomplish these risk management/mitigation surveys. The purpose of this assessment was to determine the effectiveness of the engineering controls that were installed in the facility to classify the measured noise exposure as continuous or impulse; explain how the classification pertains to AFOSH Standard 48-20, *Occupational Noise and Hearing Conservation Program*; and provide recommendations for mitigating exposure to hazardous noise.

b. *Survey Personnel*: Two Bioenvironmental Engineering Technicians, Consultative Services Division, USAFSAM/OEC.

c. *Personnel Contacted*:

(1) Bioenvironmental Engineer, 509 MDOS/SGOJ
(2) Bioenvironmental Engineering Technician, 509 MDOS/SGOJ
(3) NCOIC, Combat Arms, 509 SFS/S4C
(4) Combat Arms Instructor, 509 SFS/S4C
(5) Combat Arms Instructor, 509 SFS/S4C
(6) Combat Arms Instructor, 509 SFS/S4C

d. *Equipment*:

(1) B&K PULSE Analyzer, Type 3560-B-140, SN 2588445
(2) Larson Davis Microphone Pre-amplifier Power Supply, Type 2221, SN 0203
(3) Larson Davis Microphone, Model # 2530, SN 1492, 1485
(4) Larson Davis Microphone Pre-amplifier, Model PRM902, SN 3824
(5) Quest Calibrator, Model # QC-20, SN QF8050050

2. BACKGROUND:

a. The Whiteman AFB CATM range is partially enclosed with 20 total firing lanes (see Figures 1 and 2). The range is used to train personnel on M4 and M9 weapons firing. A noise reverberant field occurs during firing where the noise energy is reflected off the ceiling, walls, and floor surfaces, thereby increasing noise levels for a longer duration. Down-range of the firing line is a series of steel safety baffles on the ceiling that are designed to deflect stray bullets and prevent bullets from leaving the range. These panels are closely spaced, thereby reflecting acoustical energy and increasing the duration of noise levels.

Figure 1. Whiteman CATM Range Lanes 1-10

Figure 2. Whiteman CATM Range Lanes 11-20

b. Engineering controls were added to the Whiteman AFB CATM in 2012. These controls include sound-absorbing materials added to the ceiling, side walls, and overhead baffles of the range, shown in Figures 3 and 4, and quilted fiberglass panels were hung from the ceiling above the ventilation system duct at the rear of the range, shown in Figure 5.

Figure 3. Sound-Absorbing Material on the Ceiling and Side Walls

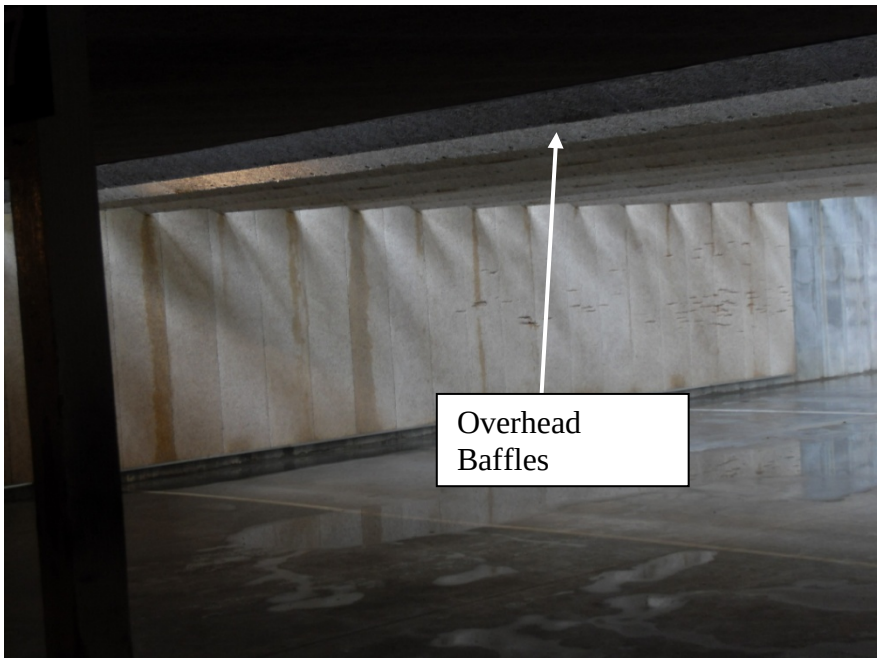

Figure 4. Sound-Absorbing Material on the Overhead Baffles

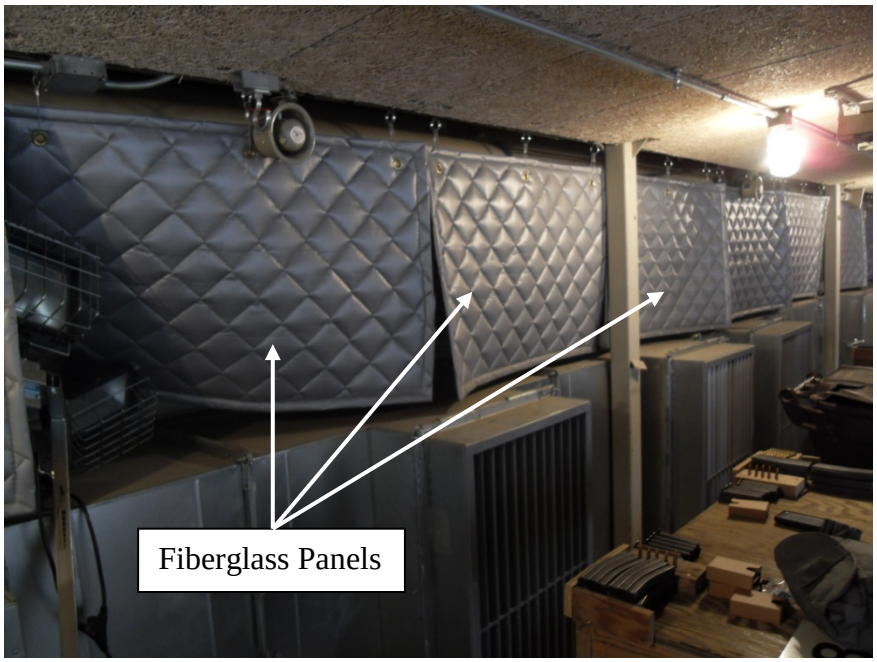

Figure 5. Hanging Quilted Fiberglass Panels

c. The maximum level of **continuous noise** that is allowed to reach the ear shall not exceed 115 dBA and the maximum level of **impulse noise** that is allowed to reach the ear shall not exceed 140 dB peak sound pressure level (SPL) according to AFOSH Standard 48-20.

3. METHODOLOGY:

a. Process Description: The CATM firing range is used to train and qualify base personnel on multiple weapon systems. The firing range has two distinct painted floor lines that are used for reference. The first point of reference is the yellow safety line. Students must stand behind this line while not actively firing a weapon. The second point of reference is the red firing line and is located 5 feet forward of the yellow safety line. The red line is where each student actively fires a weapon at a down-range target. During live-fire weapons training classes, instructors are positioned along the yellow line to ensure the range is safe and to assist students when needed. During this assessment, CATM instructors were observed wearing dual hearing protection (Howard Leight Thunder T3 earmuffs and Howard Leight Max earplugs).

b. *Sample Procedure:* The SPL time histories corresponding to individual M4 and M9 weapon firings were measured with a ¼-inch microphone placed 5 feet above ground level along the yellow safety line (see Figure 6 for microphone positions). Time histories are measured SPLs over a duration of approximately 4 seconds. This duration provided sufficient time to characterize the decay of the acoustical energy to background levels. These time histories were then used to compute acoustical decay characteristics.

c. The linear SPL decay rates, in decibels per second, were computed by selecting the linear decay phase of each time history and performing a sound level versus time analysis through the decay phase. Decay times are calculated from the linear slope from 150 dB down to 80 dB. The slope of this curve is the decay rate.

d. SPL time history data were collected in four phases to represent the spectrum of exposure scenarios typical at this range.

(1) During the first phase, three base personnel each shot an M4 on firing lanes 11-13.

(2) For the second phase, M4 data were collected while two Security Forces personnel each shot an M4 at firing lanes 11 and 12.

(3) The third phase of data collection was accomplished while one CATM instructor shot the M9 from firing lane 10.

(4) During the fourth phase, M9 data were collected while 15 base personnel each shot an M9 at firing lanes1-8 and 11-17.

e. During the first, second, and fourth phases of data collection, a minimum of 10 SPL time histories were collected at each identified microphone position. For the third phase, 5 noise pressure time histories were collected at each microphone position due to time limitations.

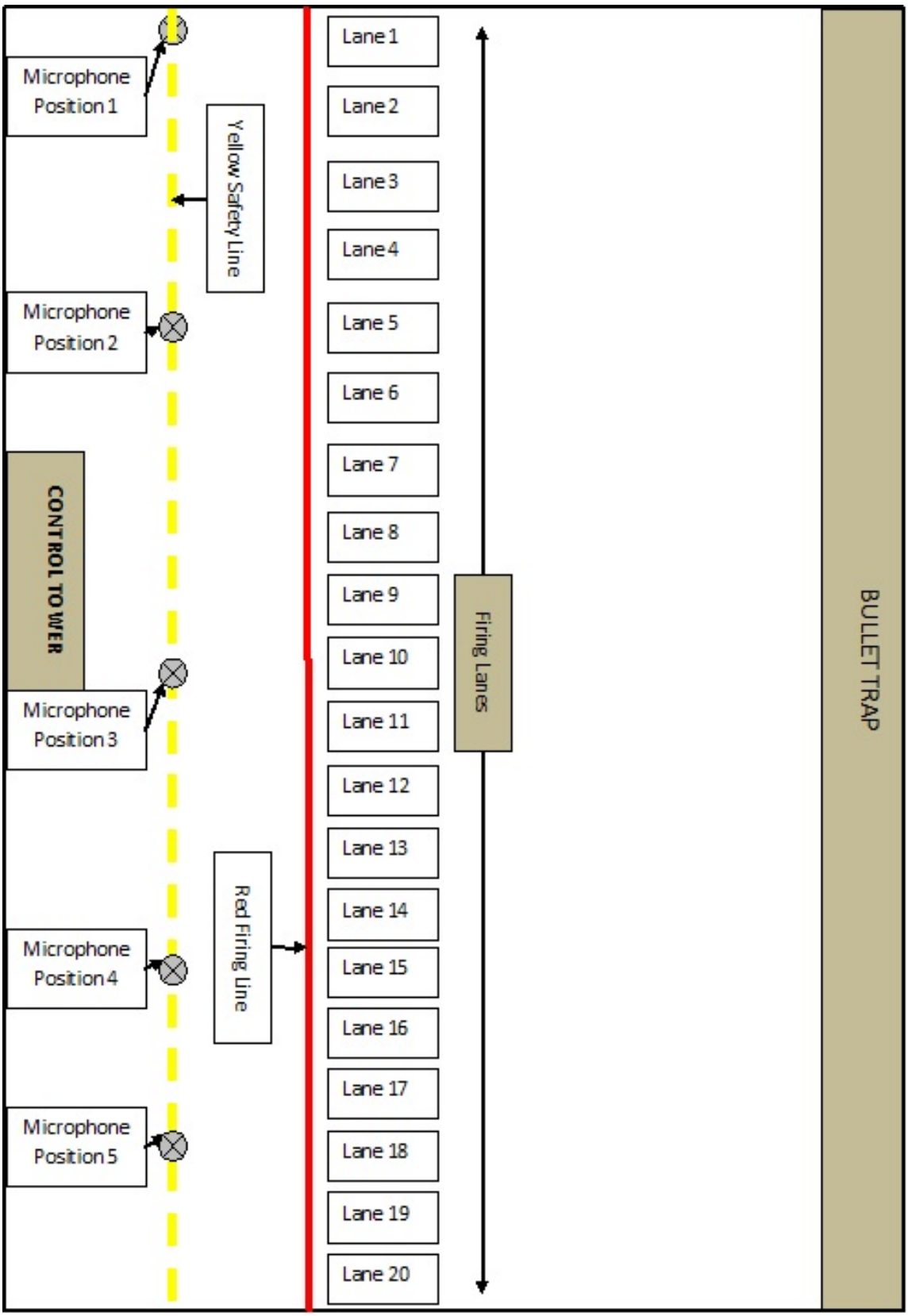

Figure 6. Whiteman AFB CATM Range Layout and Microphone Position

f. The SPL time histories were also used to calculate the average B-duration for each weapon system. The B-duration is a time measurement characterizing the primary noise impulse and subsequent significant sound pressure fluctuations. It is calculated by subtracting the point in the primary impulse, in seconds, along the SPL time history that was 20 dB below the peak SPL from the subsequent point that remained 20 dB below the peak SPL. The same calculation was performed for any remaining significant fluctuations (those having a time duration greater than 10% of the primary portion). The two values were then added together to get the overall B-duration for that impulse. For example, in Figure 7, B-duration (ms) is = $T_1 + T_2$, where T_1 (ms) = (X – V) and T_2 (ms) = (Z – Y). This process was performed for each impulse datum and averaged for each weapon type. The average B-duration was used to calculate the maximum allowable impacts per day for both single and dual hearing protection devices for each weapon system.

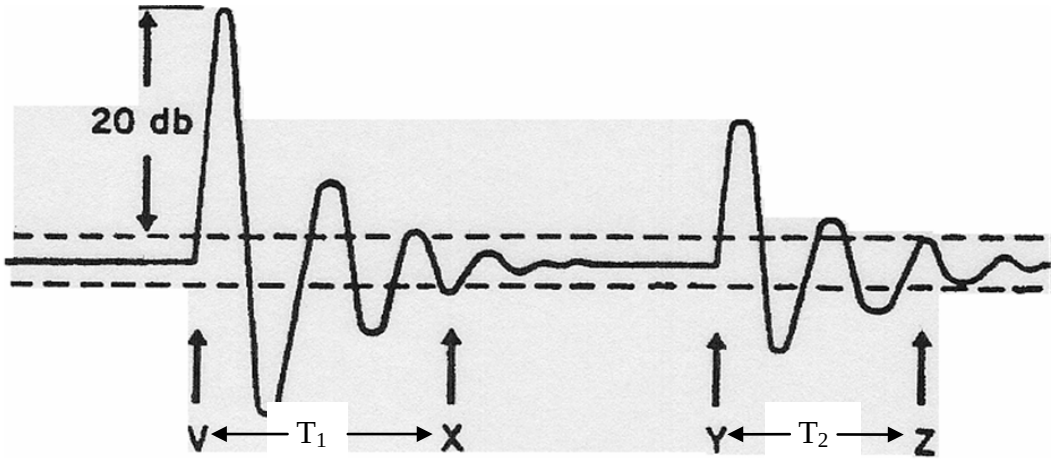

Figure 7. Example Impulse Noise Spectrum

4. RESULTS:

a. Under the monitored conditions, the noise characterization at the Whiteman AFB CATM range meets the definition of **impulse noise** IAW AFOSH Standard 48-20. The definition states that impulse noise is "a short burst of acoustic energy consisting of either a single burst or a series of bursts. The pressure-time history of a single burst includes a rapid rise to a peak pressure followed by a somewhat lower decay of the pressure envelope to ambient pressure, both occurring **within 1.0 second**. A series of impulses may last longer than 1.0 second."

b. The decay time, when averaged over multiple shots and two different types of weapons, was **0.9 seconds**. See Table 1 for a summary of noise characterization and decay times.

Table 1: Noise Characterization by Decay Time

Weapon System	Average Decay Time (s)	Average B-duration (ms)	Noise Characterization	Peak SPL (dB)	Maximum Unprotected Impulse Noise Level (dB)	Exceeds Impulse Noise Std. (Yes/No)	Maximum Allowable Impacts/Day with Single Hearing Protection*	Maximum Allowable Impacts/Day with Dual Hearing Protection*
M4	0.9	175	**Impulse**	158	140	**YES**	**7,585**	**151,700**
M9	0.9	163	**Impulse**	155	140	**YES**	**33,113**	**662,260**

* See Attachment for calculations of allowable impacts per day.

5. CONCLUSION: The engineering controls that were installed at the Whiteman AFB CATM range have effectively changed the noise classification from continuous to impulse noise; however, peak SPLs remain above the allowable unprotected level of 140 dB.

6. RECOMMENDATIONS:

a. The daily hearing protection requirement is dependent on the number of students in a training class, the type of weapon being fired, and the number of rounds fired per student. This needs to be compared to the maximum allowable impacts per day in Table 1. For example, if 20 students each fire 190 rounds from the M4, the total impacts for the day would be 3,800 (20 students x 190 rounds per student). This would allow single hearing protection to be worn, as the number is less than the maximum of 7,585 impacts per day. Consequently, if 40 students each fire 190 rounds from the M4, the total impacts per day would be 7,600 (40 students x 190 rounds per student), requiring dual hearing protection as the exposure would be greater than the maximum allowable impacts per day for single hearing protection devices, but less than the maximum allowable for dual hearing protection.

b. If CATM instructors will train students on both the M4 and M9 during the same day, the daily noise dose calculation $[(C_1 / T_1) + (C_2 / T_2) \leq 1]$ can be used to determine if the CATM instructors will be overexposed while wearing single hearing protection devices. For this calculation, C = number of rounds to be fired for each weapon system and T = maximum daily allowable impacts for each weapon system either single or dual hearing protection from Table 1. For example, if CATM trains 20 students each firing 190 rounds from the M4 (C_1 = 3,800 total impacts and T_1 = 7,585 maximum allowable impacts for single hearing protection) and 100 rounds each from the M9 (C_2 = 2,000 total impacts and T_2 = 33,113 maximum allowable impacts for single hearing protection) in the same day, the calculation would be: (3,800 / 7,585) + (2,000 / 33,113). If the result of this equation is less than or equal to 1, then single hearing protection devices will provide sufficient protection for the day. If the result of this equation is greater than one, dual hearing protection would be required.

c. CATM instructors should provide just-in-time training to students on proper use of hearing protection devices as part of classroom instruction. NIOSH has a short video on proper insertion of foam ear plugs available for download at http://www.cdc.gov/niosh/mining/products/movies/rphhi.wmv.

d. Request a follow-up assessment if any changes to the firing range are made. The assessment would determine if the in-place engineering controls still effectively reduce the decay time of gunfire noise to 1 second or less and classify the noise as impulse.

7. If you have any further questions regarding this report, please contact TSgt Jerimiah Jackson at DSN 798-3312 or jerimiah.jackson@us.af.mil. Please direct any questions or comments regarding Industrial Hygiene Consultative support to Maj Eric Sawvel at DSN 798-3328 or eric.sawvel@us.af.mil. To improve our services, please complete the critique located at https://www.surveymonkey.com/s/OECUSTOMERSURVEY.

JERIMIAH M. JACKSON, TSgt, USAF
Industrial Hygiene Consultant

Attachment:
Allowable Impacts/Day Calculations for Whiteman AFB CATM Firing Range

Attachment
Allowable Impacts/Day Calculations for Whiteman AFB CATM Firing Range

Per AFOSH Standard 48-20, Attachment 2, the equation for calculating the allowable number of exposures per day is:

$N_1 = 10^x$ where $x = 1/5 * [177 – L + 6.64 * LOG_{10}200/T]$
$N_2 = 20 \times N_1$
N_1 = allowable number of impulses/day (single protection)
N_2 = allowable number of impulses/day (double protection)
L = measured peak sound pressure level, in dB
T = measured B-duration in milliseconds

M9 allowable impacts per day calculations:
$N_1 = 10^x$, where $x = 1/5 * [177 – L + 6.64 * LOG_{10}200/T]$
L = 155 – value taken from AFOSH Standard 48-20, Table A2.2
T = 163
x = (1/5) * [177 – 155 + 6.64 * LOG10(200/163)]
x = (1/5) * [177 – 155 + 6.64 * LOG10(1.23)]
x = (1/5) * [177 – 155 + 6.64 * .088]
x = (1/5) * [177 – 155 + .59]
x = (1/5) * [22.59]
x = 4.52

$N_1 = 10^x$
$N_1 = 10^{4.52}$
N_1 = 33,113

$N_2 = 20 * N_1$
N_2 = 20 * 33,113
N_2 = 662,260

M4 allowable impacts per day calculations:
$N_1 = 10^x$, where $x = 1/5 * [177 – L + 6.64 * LOG_{10}200/T]$
L = 158
T = 175
x = (1/5) * [177 – 158 + 6.64 * LOG10(200/175)]
x = (1/5) * [177 – 158 + 6.64 * LOG10(1.14)]
x = (1/5) * [177 – 158 + 6.64 * .058]
x = (1/5) * [177 – 158 + .39]
x = (1/5) * [19.39]
x = 3.88

$N_1 = 10^x$
$N_1 = 10^{3.88}$
N_1 = 7,585

$N_2 = 20 * N_1$
N_2 = 20 * 7,585
N_2 = 151,700